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The Relation Between Spirometry Parameters and Tissue Doppler Echocardiography Findings in Children with Asthma

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Abstract Background: Despite advanced understanding of the asthma pathophysiology as it a complex immune-mediated multi-factorial disease, some of asthma systemic effects of are still not well defined. Objectives: To find out the relation between spirometry parameters and heart function assessed by tissue Doppler echocardiography in children with Asthma. Methods: One hundred and five child were enrolled in this study (35 Child with mild persistent asthma (13.66 ± 0.49 years), 35 child with intermittent asthma (13. 76 ± 0.39 years) and 35 child as a control (13.54 ± 0.36 years)). Spirometry parameters [forced vital capacity (FVC), forced expiratory volume in the first second of FVC (FEV_1), the ratio between FVC1 and FVC (FVC_1/FVC) and peak expiratory flow (PEF)] were done for all individuals. Echocardiography parameters were evaluated using conventional and tissue Doppler imaging (TDI). Results: In children there is significant difference of pulmonary function tests according to severity of disease. Echocardiography revealed no significant difference by conventional echo but there is difference in diastolic function of both ventricles and systolic functions of RV by TDI. There is some correlations between spirometry measurements and TDI parameters especially right ventricular diastolic dysfunction parameters (in mild persistent asthma FVC1 is positively correlated with Tricuspid E` and negatively with E/E` and FVC is positive correlated with tricuspid A` and tricuspid S`, while FVC1/FVC positively correlated with tricuspid E`/A` and S`, while in Children with intermittent asthma **maximal expiratory flow brought to 25-75% of the vital capacity** (MEF 25-75%) is positively correlated with TDE (S`) & (E`) peak velocities of tricuspid valve and PEF is positively correlated with IVRT). We also found that a negative correlation between tricuspid E/E` and duration of illness while a positive correlation with mitral E/E` and duration of illness in asthmatic children. Conclusion: Changes in echocardiographic parameters, evaluated by TDI, were observed in mild and intermittent asthma patients even with normal conventional echocardiography and also asthma severity can be predicted using TDI.

Keywords Spirometry Parameters, Asthma pathophysiology

1. Introduction

Asthma is a common chronic disease of respiratory system affecting up to 18% of population. There is a complex interaction between respiratory diseases and cardiovascular function. In asthma there were attacks of recurrent hypoxemia, and hypercarbia that with various released mediators and cytokines lead to pulmonary vasoconstriction and development of pulmonary hypertension [1].

Pulmonary hypertension developed due to multiple factors beside pulmonary vasoconstriction, including the distortion of pulmonary vessels by parenchymal changes, increased cardiac output, and blood viscosity from polycythemia secondary to hypoxia. Asthmatic patient develop pulmonary hypertension as a sequale of chronic inflammation and recurrent hypoxia. Severe asthma can lead to cor pulmonale later in life [2].

Cor pulmonale starts with RV diastolic dysfunction of the right ventricle that depends on RV hypertrophy and total pulmonary resistanc[3]. The interaction between both ventricles with increased LV afterload can lead also to LV) diastolic dysfunction [4].

Tissue Doppler imaging (TDI) by echocardiography through its quantitative measurement of regional myocardial velocities can detect subclinical RV abnormalities when conventional echocardiography fail [5].

The relation between spirometry parameters reflecting severity of asthma and TDI is not well understood.

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2. Aim of the Work

To find out the relation between spirometry parameters and heart function assessed by tissue Doppler echocardiography in children with Asthma.

3. Patients and Methods

Study population:

This is a Cross sectional study carried out on 105 child (35 of them with mild persistent asthma, 35 with intermittent asthma according to Global Initiative for Asthma (GINA) report 2006 in remission for at least 4 weeks **and 35 matched healthy children) on regular follow up at the Pediatric Allergy & Pulmonology Outpatient Clinics, Al-Azhar university Hospitals (Al-Hussien & Bab EL-Shairia)** during the period from January 2013- May 2015.

The patients were excluded if moderate or severe persistent asthma, other co-morbid diseases (upper or lower respiratory infection, allergic rhinitis, gastroesophageal reflux, obesity; chronic cardiovascular disease or renal impairment), acute attack of asthma during the last 4 weeks and use of oral steroids in the last 4 weeks or refusal of parents of patients to participate in the study.

Methods

The following was done For all subjects:

1. Informed written consent from the parents or persons responsible for the children to participate in the study.
2. **Detailed history** was taken from parents especially of pulmonary symptoms and family history of allergy.
3. **Thorough physical examination** were performed including the height, body weight, body mass index, heart rate, respiratory rate, and blood pressure for all children.
4. **Routine laboratory investigations including** CBC, CRP & ESR.
5. **Plain chest X- Ray.**
6. **Pulmonary function tests using spirometry** [forced vital capacity (FVC), forced expiratory volume in the first second of FVC (FEV_1), the ratio of FEV1 to FVC, and peak expiratory flow (PEF)]. For each patient three technically acceptable measurements were performed and the highest value was taken [6].
7. 12 lead electrocardiogram was done for each patient.
8. **ECG-gated transthoracic echocardiography was done by** Single experienced observer who was blinded to the patient's respiratory status using *Philips iE33 echo machine with S5-1 probe (in adult echo unit, Cardiology department).* The patients were studied without sedation while they were lying quietly in the supine and left lateral decubitus positions. According to standard techniques by the American Society of Echocardiography the standard views (parasternal long and short axises, apical 4 chamber, 2 chamber and 3 chambers and subcostal views) and modes (2D, M-mode, pulsed wave, continuous wave, color Doppler and TDI) were obtained [7].

The following measurements were taken:

1) **LV** End-diastolic and end-systolic dimensions, RV anterior wall thickness, and end-diastolic dimension [7].
2) **Trans-mitral and tricuspid pulse-wave** peak velocities during early diastole **(E),** peak velocity during late diastole **(A)** and deceleration time **(DT)** of the early diastolic velocity.
3) **Tissue Doppler imaging (TDI) of** peak systolic **(S′)** and early **(E′)** and late diastolic velocities and from the apical four-chamber view. Sample volume was placed in apical 4 chamber view at the lateral tricuspid annulus and the average medial and lateral mitral annulus. The ratio of early to late diastolic annular velocities was calculated. Cardiac time intervals, comprising right ventricle including isovolumetric contraction and relaxation time **(IVCT)**, **(IVRT)**, and ejection time **(ET)** from the beginning to the end of the pulmonary flow, was measured. Doppler-derived myocardial performance index **(MPI)** was calculated as the IVCT and IVRT divided by the ejection time (ET) [7].

Statistical analysis:

Data were collected and analyzed using IBM SPSS software package version 22.0 (IBM corporation and others, USA). Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean± standard deviation and median. Significance of the obtained results was judged at the 5% level.

The used tests were: Chi-square for categorical variables (to compare between different groups), **Fisher's Exact or Monte Carlo correction** when more than 20% of the cells have expected count less than 5, **F-test (ANOVA)** For normally quantitative variables, to compare between more than two studied groups, and Post Hoc test (LSD) for pair wise comparisons, **Mann Whitney test for** abnormally quantitative variables, to compare between two studied groups, **Kruskal Wallis test for** abnormally quantitative variables, to compare between more than two studied groups and **Pearson coefficient to** correlate between two normally quantitative variables.

4. Results

This case control study was designed to assess the left and right ventricular function in children with bronchial asthma and to detect the correlation between spirometry parameters and tissue Doppler echocardiography. Both asthmatic cases and controls were properly matched regarding age, sex, BMI, age at diagnosis and bronchial asthma disease duration., birth order, family size, parental education and parental

occupation. The differences between the two asthma groups (mild and intermittent) and control were statistically insignificant (P >0.05). (Table 1).

As regard bronchial asthma symptoms and signs no significant difference apart from high presence of inspiratory wheeze in mild cases than intermittent asthmatic patients.

The daytime symptoms present in 17.1% of mild and 5.7% of intermittent cases. The limitation of activity present in 2.9% in mild asthmatic patients while 1.1% of intermittent asthmatic patients. The night time symptoms present in 31.4% of mild cases and 3.1% of intermittent cases. Increase rescue medication use present in 11.4% of mild cases and 17.1% of intermittent cases. No breathing difficulty in any cases as no severe cases included while routine follow up done in 88.6% in mild cases and all intermittent cases. The inspiratoy wheeze present in 45.7% of mild cases and 25.7% of intermittent cases with p value <0.001 table (2).

However regarding peak expiratory flow rate (PEFR), asthmatic children showed significantly lower values (253.8±17.4 L/sec) than controls (271.9±20.6 L/sec) (P <0.01) (Table 2).

Table 1. Comparison between the different studied groups according to personal history

	Mild asthma (n = 35)	Intermittent asthma (n = 35)	Control (n = 35)	Test	P value
Age (years)	13.66 ± 0.49	13. 76 ± 0.39	13.54 ± 0.36	**F=0.75**	**0.09**
Male gender (%)	**17(48.6%)**	**21(60%)**	15(42.9%)	X^2 =2.134	0.344
BMI (kg/m^2)	15.74 ± 2.56	16.88 ± 2.79	17.21 ±1.71	F=0.659	0.29
Age at diagnosis (years)	2.16 ± 0.77	2.47 ± 1.45	**2.55±1.3**	Z=0.265	0.791
Disease duration (mo)	6.54 ± 2.56	7.31 ± 2.09	-	Z=0.724	0.623

χ^2: Chi square test
Z: Z for Mann Whitney test
F: F test (ANOVA), Sig. bet. groups was done using Post Hoc Test (LSD)

Table 2. Symptoms and signs of asthmatic children

	Mild asthma (n = 35)	Intermittent asthma (n = 35)	χ^2	p
Day time symptoms	**6(17.1%)**	**2(5.7%)**	2.258	^{FE}p=0.259
Any limits to activity	**1(2.9%)**	**6(17.1%)**	3.968	^{FE}p=0.106
Night time symptoms	**11(31.4%)**	**13(3.1%)**	0.254	0.615
Increase Rescue medication use	**4(11.4%)**	**6(17.1%)**	0.467	0.495
Routine follow up	**31(88.6%)**	**35(100%)**	4.242	^{FE}p=0.114
Inspiratory wheeze	**16 (45.7%)**	**9 (25.7%)**	20.265*	<0.001*

χ^2: Chi square test
*: Statistically significant at $p \leq 0.05$
FE: Fisher Exact for Chi square test

Table 3. LV conventional echo of all individuals

	Mild asthma (n = 35)	Intermittent asthma (n = 35)	Control (n = 35)	F	p
FS	39.51 – 3.0	38.46 ± 2.63	38.83 ± 3.73	1.011	0.367
EF	67.36 ± 1.83	67.90 ± 2.36	68.0 ± 2.21	1.129	0.327
LVEDD	33.86 ± 3.09	33.74 ± 4.45	33.94 ± 3.86	1.808*	0.08
LVESD	15.19 ± 1.49	15.62 ± 1.57	15.20 ± 1.31	0.982	0.378
Mitral E	76.38 ±4.81	75.90 ± 4.51	77.60 ± 4.99	1.186	0.310
Mitral A	40.12 ± 1.57	38.51 ± 1.08	40.23 ± 1.86	13.698*	<0.001*
Sig. bet. groups	p_1<0.001*, p_2=0.757, p_3<0.001*				
Mitral E/A	1.91 ± 0.14	1.97 ± 0.14	1.93 ± 0.13	2.060	0.133
l IVRT	101.94 ± 4.37	102.35 ± 4.39	95.37 ± 6.36	20.445*	<0.001*
Sig. bet. groups	p_1=0.734, p_2<0.001*, p_3<0.001*				

F: F test (ANOVA), Sig. bet. groups was done using Post Hoc Test (LSD)
p_1: p value for comparing between Mild-p and Intermittent
p_2: p value for comparing between Mild-p and control
p_3: p value for comparing between Intermittent and control
*: Statistically significant at $p \leq 0.05$

Table 4. RV conventional echo of all individuals

	Mild asthma (n = 35)	Intermittent asthma (n = 35)	Control (n = 35)	F	p
RV wall thick.	0.67 ± 0.06	0.76 ± 0.14	0.63 ± 0.06	17.557*	<0.001*
Sig. bet. groups	p_1=0.102, p_2<0.001*, p_3<0.001*				
RV diameter	1.71 ± 0.19	1.76 ± 0.11	1.75 ± 0.26	0.536	0.587
Tricusp E	74.79 ± 4.11	71.46 ± 4.32	69.05 ± 11.69	5.067*	0.008*
Sig. bet. groups	p_1=0.069, p_2=0.002*, p_3=0.185				
Tricusp A	39.30 ± 5.56	40.07 ± 2.69	39.49 ± 5.61	0.247	0.781
Tricusp E/A	1.93 ± 0.23	1.79 ± 0.21	1.78 ± 0.36	3.384*	0.038*
Sig. bet. groups	p_1=0.039*, p_2=0.019*, p_3=0.767				

F: F test (ANOVA), Sig. bet. groups was done using Post Hoc Test (LSD)
p_1: p value for comparing between Mild-p and Intermittent
p_2: p value for comparing between Mild-p and control
p_3: p value for comparing between Intermittent and control
*: Statistically significant at $p \leq 0.05$

Table 5. TDI parameters of all individuals

LV or RV	Parameter	Mild asthma	Intermittent asthma	Control	F	p
Mitral Annulus	**E′**	15.04 ± 0.25	14.99 ± 0.21	15.04 ± 0.29	0.441	0.644
	A′	6.16 ± 0.03	6.15 ± 0.03	6.13 ± 0.19	0.887	0.415
	E′/A′	2.44 ± 0.05	2.44 ± 0.03	2.46 ± 0.11	0.830	0.439
	S′	7.81 ± 0.38	7.02 ± 0.51	7.96 ± 0.41	46.792*	<0.001*
	Sig. bet. groups	p_1<0.001*, p_2=0.164, p_3<0.001*				
	E/E′	5.08 ± 0.36	5.06 ± 0.28	5.16 ± 0.35	0.864	0.424
Tricuspid Annulus	**E′**	15.83 ± 0.89	15.87 ± 0.82	12.98 ± 1.10	107.443*	<0.001*
	Sig. bet. groups	p_1=0.850, p_2<0.001*, p_3<0.001*				
	A′	6.23 ± 0.78	6.31 ± 0.57	8.40 ± 1.10	74.528*	<0.001*
	Sig. bet. groups	p_1=0.692, p_2<0.001*, p_3<0.001*				
	E′/A′	2.57 ± 0.31	2.53 ± 0.28	2.19 ± 0.61	1711.780*	<0.001*
	Sig. bet. groups	p_1=0.879, p_2<0.001*, p_3<0.001*				
	S′	7.21 ± 0.67	7.22 ± 0.83	8.93 ± 0.89	53.527*	<0.001*
	Sig. bet. groups	p_1=0.966, p_2<0.001*, p_3<0.001*				
	IVRT	64.63 ± 4.74	64.88 ± 5.76	49.14 ± 2.12	141.892*	<0.001*
	Sig. bet. groups	p_1=0.813, p_2<0.001*, p_3<0.001*				
	MPI	49.77 ± 4.0	50.31 ± 3.15	43.22 ± 2.46	51.137*	<0.001*
	Sig. bet. groups	p_1=0.488, p_2<0.001*, p_3<0.001*				
	E/E′	4.75 ± 0.44	4.51 ± 0.34	5.37 ± 1.01	15.540*	<0.001*
	Sig. bet. groups	p_1=0.808, p_2=0.321, p_3=0.217				

F: F test (ANOVA), Sig. bet. groups was done using Post Hoc Test (LSD)
p_1: p value for comparing between Mild-p and Intermittent
p_2: p value for comparing between Mild-p and control
p_3: p value for comparing between Intermittent and control
*: Statistically significant at $p \leq 0.05$

The left ventricular dimensions and systolic and diastolic functions among asthmatic children and controls were assessed through conventional Doppler echocardiography and found no significant difference between the three groups; the left ventricular echocardiographic measurements and systolic function among mild asthmatic cases was: LVEDD (33.86±3.09mm), LVESD (15.19±1.49mm), FS (39.51±3.0%), EF (67.36±1.38%), in intermittent cases: LVEDD (33.74±4.45mm), LVESD (15.62±1.57mm), FS (38.46±2.63%), EF (67.90±2.36%) and in controls: LVEDD (33.94±3.86mm), LVESD (15.20±1.31mm), FS (38.83±3.0%), EF (68.0±2.21%) (P >0.05) (table 3).

Also the left ventricular diastolic echocardiographic function among mild cases: Mitral valve peak E velocity (76.38±4.81 cm/sec) and Mitral valve E/A ratio (1.91±0.14) were insignificantly different than those among intermittent cases: (75.90±4.51) and (1.97±0.14) and controls: (77.60±4.99) and (1.93±0.13) respectively (P >0.05) (Table 3). However, the Mitral valve peak A velocity was higher in mild cases (40.12±1.57 cm/sec) than control (40.23±1.86

cm/sec) and low mitral A wave in intermittent case (38.51±1.08) than control with P value <0.001 (table 3).

Also Mitral valve IVRT was lower in cases (95.37±6.36 sec) than mild cases (101.94±4.37 sec) and intermittent cases (102.35±4.39) with P value <0.001.

However, the RV wall thickness was statistically higher among intermittent asthmatic children (0.76 ± 0.14 cm) than mild cases (0.67 ± 0.06 cm) and controls (0.63 ± 0.06 cm) (P <0.01). But, the right ventricular diameter were insignificantly different between mild cases (1.71 ± 0.19 cm), intermittent cases (1.76 ± 0.11 cm) and controls (1.75 ± 0.26cm) with p value <0.05.

The conventional pulsed Doppler indices of tricuspid valve (Peak E velocity, peak A velocity and the ratio of peak E to peak A) were significantly different among mild asthmatic cases (74.79±4.11 cm/sec and 1.93±0.23 respectively) than intermittent cases (71.46±4.32 and 1.79±0.21) and controls (69.05±11.69 cm/sec and 1. 78±0.36 respectively) (P <0.05) (Table 4). While the trans-tricuspid A wave was insignificant different from mild asthmatic cases (39.30±5.56 cm/sec) than intermittent cases (40.07±2.69 cm/sec) and controls (39.49±5.61 cm/sec) with p value >0.05.

Tissue Doppler study of the left ventricular diastolic function revealed that peak mitral annulus E′ velocity (15.04±0.25 cm/ sec), peak A′ velocity (6.16±0.03 cm/sec), E′/A′ ratio (2.44±0.05) and E/E′ (5.08±0.36) among mild asthmatic cases, in intermittent asthmatic children was (14.99±0.21 cm/ sec), (6.15±0.03 cm/ sec), (2.44±0.03) and (5.06±0.28) and in controls was (15.04±0.29 cm/ sec), (6.13±0.19 cm/ sec), (2.46±0.11) and (5.16±0.35) with no significant difference (P value >0.05) (table 5 and figure 1).

In studying the LV systolic function by TDI using mitral annular S′ the velocity was markedly reduced in intermittent asthma cases (7.02±0.51 cm/ sec) than mild asthma children (7.81±0.38 cm/ sec) and control children (7.96±0.41 cm/ sec) and this difference was statistically significant (p value <0.001).

Table 6. Spirometry parameters of all individuals

	Mild asthma	Intermittent asthma	Control	F	p
FVC	88.77 ± 2.60	91.77 ± 2.60	88.51 ± 4.94	9.067*	<0.001*
Sig. bet. groups	p_1=0.001*, p_2=0.763, p_3<0.001*				
FVC1	96.34 ± 1.21	99.23 ± 0.81	102.31±3.93	53.274*	<0.001*
Sig. bet. groups	p_1<0.001*, p_2<0.001*, p_3<0.001*				
FVc1/FVC	108.64 ± 2.44	111.64 ± 2.44	113.57 ± 2.49	35.778*	<0.001*
Sig. bet. groups	p_1<0.001*, p_2<0.001*, p_3=0.001*				
PEF	89.17 ± 4.16	92.09 ± 4.02	90.89 ± 5.03	3.831*	0.025*
Sig. bet. groups	p_1=0.007*, p_2=0.108, p_3=0.260				

F: F test (ANOVA), Sig. bet. groups was done using Post Hoc Test (LSD)
p_1: p value for comparing between Mild-p and Intermittent
p_2: p value for comparing between Mild-p and control
p_3: p value for comparing between Intermittent and control
*: Statistically significant at p ≤ 0.05

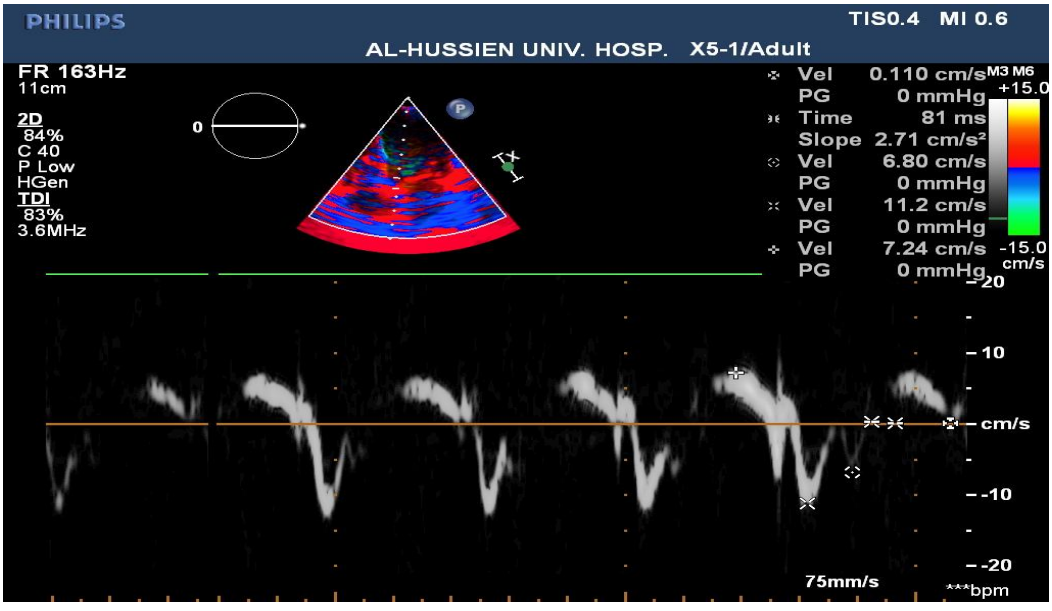

Figure (1). TDI mitral valve septal annulus (Em: 11.2 cm/sec), Am (6.5cm/sec), Sm (7.2cm/sec), E/E'(7.7) Normal tissue Doppler image parameters. **Patient No. (19) with mild asthma**

The right ventricular diastolic function revealed that peak E′ velocity (15.83±0.89 cm/ sec), peak A′ velocity (6.23±0.78 cm/sec), E′/A′ ratio (2.57±0.31), Isovolumetric Relaxation Time (IVRT) of the lateral tricuspid annulus (64.63±4.74 sec) and E/E′ (4.75±0.44) in mild asthmatic children while in intermittent asthmatic children was (15.87±0.82 cm/ sec), (6.31±0.57 cm/sec), (2.53±0.28), (64.88±5.76 sec) and (4.51±0.34), respectively and in controls was (12.98±1.10 cm/ sec), (8.40±1.10 cm/sec), (2.19±0.61), (49.14±2.12 sec) and (5.37±1.01) respectively and this difference was statistically significant (table 5).

However regarding the right ventricular systolic function in asthmatic children have significant lower systolic velocities in the right ventricular free wall lateral S′in cases (7.21±0.67 and 7.22±0.83 cm/sec) and high MPI in cases (49.77±4.0 and 50.31±3.15) while in the matched control children was (8.93±0.89 cm/ sec) and (43.22±2.46) respectively with P value <0.001.

There were a statistically significant difference among different groups in selected paramters of electronic spirometry (FVC, FVc1, FVc1/FVC and PEF) with p value < 0.001 (table 6).

In children with mild persistent asthma FVC1 is positively correlated with Tricuspid E` **(r= 0.538, P <0.001),** and negatively with E/E` **(r= -0.38, P =0.023)** and FVC is positive correlated with tricuspid A` **(r= 0.341, P =0.045)** and tricuspid S` **(r= 0.46, P =0.005)** in mild persistent asthma while FVC1/FVC positively correlated with tricuspid E`/A` **(r= 0.39, P =0.022)** and S` **(r= 0.45, P =0.006).**

Children with intermittent asthma maximal expiratory flow brought to 25-75% of the vital capacity (MEF 25-75%) is positively correlated with TDE S` **(r= 0.46, P =0.006)** & E` **(r= 0.35, P =0.043)** of tricuspid valve.

We also found that a negative correlation btween tricuspid E/E` and duration of illness **(r= -036, P =0.003)** while a positive correlation with mitral E/E` and duration of illness **(r= 0.46, P <0.001)** in asthmatic children.

5. Discussion

Asthma is a complex immune-mediated multifactorial disease in which there are recurrent episodes of airway narrowing, resulting in difficulty breathing and coughing, and in which the airway narrowing is variable. Sustained pulmonary vasoconstriction and narrowing of the pulmonary vasculature which may develop pulmonary hypertension in asthmatic patients is believed to result from recurrent exposure to hypoxemia besides chronic and sustained inflammation in the airway of those patients which lead to right heart enlargement with ventricular hypertrophy, and impaired cardiac function, known as cor pulmonale [2].

Little is known about the function of the right ventricle early in the disease.

Spirometry is the easiest and most commonly performed measurement of lung function. It uses forced ventilatory manoeuvres to assess maximal flow rates and dynamic lung volumes.

As the patient performs forced inspiratory and expiratory manoeuvres through the mouthpiece of the spirometer, flow rates and time are measured. Volumes are calculated from these parameters.

Older school children and adolescents may be able to perform satisfactory flow–volume loops on most electronic spirometers.

Chronic chest disease resulted in early RV diastolic dysfunction followed by LV diastolic dysfunction from interplay between ventricles. The degree of RV diastolic dysfunction is proposed to depend on RV hypertrophy and total pulmonary resistance. TDI enables the detection of right ventricular dysfunction in the early stages of respiratory disease [3].

In this study both groups (Asthmatic children and controls) were properly matched together regarding age, sex and socioeconomic standard.

Regarding demographic data 55% of asthmatic children were males and rest of them are females these agree with Elmasry, et al. [8] who reported that bronchial asthma is more common in male compared to female patients.

In the present study it was found that all the left ventricular dimensions and functions by conventional echocardiography among asthmatic children were insignificantly differ from controls.

A study done in by Elmasry et al. [8] to assess the left ventricular function among asthmatic children both during and after resolution of acute severe asthma found that patients had significant higher trans-mitral peak A velocity and lower E/A ratio (i.e. impaired LV diastolic function) during acute asthma exacerbation but disappeared after its resolution and concluded that trans-mitral inflow velocity patterns during acute severe asthma in children are suggestive of altered LV preload due to an acute transient elevation in pulmonary artery pressure secondary to the altered lung mechanics and not reflection of intrinsic LV diastolic dysfunction.

In the current study, significant differences between groups were found regarding E' and A' evaluated in the tricuspid and mitral annuli. In addition, the MPI of the right ventricle was significantly higher in the group with intermittent asthma. Interestingly, symptoms and signs of respiratory stress were similar in both groups. Taken together, these findings suggest that echocardiographic parameters, especially TDI parameters, can be useful as a complementary evaluation for patients with asthma, allowing the early detection of repercussions on the heart.

The relation and interaction between lung and cardiovascular function is complex (cardio-pulmonary axis). Right ventricular hypertrophy was present in asthmatic patients as Shedeed et al. [3], Ozdemir et al. [2], Han et al. [9] and Zedan et al. [10], but not De-Paula et al. [11], that found no RV hypertrophy unlike these studies but De-Paula studied only 20 asthmatic patients.

Right ventricular hypertrophy begins very early in the course of the disease, they explained this process as The RV is a thin-walled, compliant, low pressure chamber that

pumps the same stroke volume as the left ventricle (LV) with 25% of the stroke work because of the normally low resistance of the pulmonary vasculature [3].

Moreover, in the current study the conventional Doppler echocardiogram revealed statistically significant difference between the controls and the group with asthma regarding peak velocities during the early diastole and atrial contraction (E, A and E/A) evaluated in the annulus of the tricuspid valves and only A wave when evaluated at the mitral valve. This finding agree with De-Paula et al. [11], and Zeybek et al. [5] who found that tricuspid E velocity, E/A ratio and isovolumetric relaxation time (IVRT) were significantly different in mild asthmatics and control subjects compared to those among moderate and severe cases. In contrary, Shedeed et al. [3] found no significant differences in these variables among controls and a group with asthma or in between the different degrees of asthma severity.

A number of studies have demonstrated that patients with asthma exhibit diastolic dysfunction [3], [5], [10]. Indeed, in this study significant differences between both asthma groups and the control group regarding myocardial diastolic velocities E', A' and E'/A' ratio evaluated in the tricuspid annulus. Similar finding were appear in the mitral valve annulus, with myocardial velocity reduction in early diastole and an increase in atrial contraction. A significant increase in IVRT was also found in the two groups of asthma, resulting in significant increase in the MPI.

Myocarial Performance Index (MPI) is a simple and useful clinical index of global ventricular function, and it is reported to be independent of heart rate and ventricular geometry. For this reason, MPI is used to evaluate the cardiac effects of multiple systemic diseases. In patients with chronic obstructive lung diseases, the longer IVRT and MPI of the right ventricle the subclinical RV dysfunction [12].

Vitarelli et al. [13] stated that the parameters of TDI-determined RV dysfunction were complementary to indices of conventional echocardiography and were correlated with respiratory function tests in patients with chronic obstructive pulmonary disease. In these patients, subclinical pulmonary hypertensionand chronic inflammatory mediators lead to RV dysfunction and TDI was found to be useful in showing RV functions.

The TDE parameters of children included in the study were all normal according to patient age. However, a significant difference of TDI parameters in asthmatic patients may support the presence of subclinical RV dysfunction.

Regarding the selected paramters of spirometry (FEV1, FEV1/FVC, and PEF), are the best predictors of disease severity in children with asthma [14].

In previous studies, different correlations were reported between respiratory function tests and TDE findings in asthmatic children like Zeybek et al. [5].

In the current study, we found that in children with mild persistentasthmaFVC1 is positively correlated with Tricuspid E` and negatively with E/E` and FVC is positive correlated with tricuspid A` and tricuspid S` in mild persistent asthma while FVC1/FVC positively correlated with tricuspid E`/A` and S`.

Children with intermittent asthma MEF 25-75% is positively correlated with TDI (S`) & (E`) of tricuspid valve.

PEF is positively correlated with IVRT while Ozdemir et al. [2] stated that PEF was negatively correlatedWith the E`/A` myocardialdiastolic velocities of the tricuspid annulus.

We also found that a negative correlation btween tricuspid E/E`and duration of illness while a positive correlation with mitral E/E` and duration of illness in asthmatic children.

This means patients with bronchial asthma have right ventricular dysfunction and the severity of the functional impairment is parallel with the severity of the disease and right Ventricular subclinical diastolic dysfunction than left ventricle especially with long duration of illness.

Massoud, et al. [15] stated that there is an evidence for the role of inflammation in patient with bronchial asthma particularly among severely asthmatics on myocardial functions where such patients have chronic and sustained inflammation, which increases at the time of an exacerbation of respiratory symptoms. Various mediators and cytokines are produced during the early and late phases, including interleukinssuch as IL-1 beta, IL-2, IL-6, IL-8, IL-10, as well as tumor necrosis factor-alpha (TNF-a). These mediators are potent depressants of cardiac contractility and long term exposure resulting in cumulative effect on cardiac function.

This means that disease severity can be predicted using TDI. Identifying patients with increased risk of ventricular dysfunction may have important implications for treatment.

6. Conclusions

Although the clinical and conventional echocardiographic findings of asthmatic children were apparently normal, tissue Doppler echocardiographic study revealed subclinical right ventricular dysfunction, which is positively correlated with the severity of asthma. This signify the diagnostic value of tissue Doppler imaging in the early detection and monitoring of such deleterious effects among asthmatic patients.

REFERENCES

[1] Reddel HK, Bateman ED, Becker A, et al.: A summary of the new GINA strategy: a roadmap to asthma control European Respiratory Journal. 2015; 56(3): 1-18. doi: 10.1183/13993003.00853-2015.

[2] Ozdemir O, Ceylan Y, Hasan R C, et al.: Assessment of Ventricular Functions by Tissue Doppler Echocardiography in Children with Asthma. Pediatr Cardiol. 2012: 012: 493-500.

[3] Shedeed SA: Right ventricular function in children with bronchial asthma: a tissue Doppler echocardiographic study.

Pediatr Cardiol. 2010: 31: 1008–1015.

[4] Coghlan J and Davar J: How should we assess right ventricular function in 2008. Eur Heart J. 2007: 9(suppl H): H22–H28.

[5] Zeybek C, Yalcin Y, Erdem A, et al. Tissue Doppler echocardiographic assessment of cardiac function in children with bronchial asthma. Pediatr Int. 2007; 49(6): 911-917. doi:10.1111/j.1442-200X.2007.02486.x.

[6] Ranu H, Wilde M, Madden B. Pulmonary function tests. Ulster Med J. 2011; 80(2): 84-90.

[7] Grapsa J, Dawson D, Nihoyannopoulos P: Assessment of right ventricular structure and function in pulmonary hypertension. J Cardiovasc Ultrasound 2011; 19: 115–125.

[8] Elmasry OA, Attia HM, AbdelFattah NM: Assessment of left ventricular diastolic function in bronchial asthma: Can werely on transmitral inflow velocity patterns? *Egypt J Pediatr Allergy Immunol* 2006; 4(2): 61-69.

[9] Han MK, McLaughlin VV, Criner GJ, et al.: Pulmonary diseases and the heart. Circulation 2007; 116: 2992-3005.

[10] Zedan M, Alsawah GA, El-Assmy MM, Hasaneen et al.: Clinical asthma phenotypes: is there an impact on myocardial performance? Echocardiography. 2012; 29(5): 528–534. doi: 10.1111/j.1540-8175.2011.01635.x.

[11] De-Paula CR, Magalhães GS, Jentzsch NS, et al. Echocardiographic Assessment of Ventricular Function in Young Patients with Asthma. Arq Bras Cardiol. 2018; 110(3): 231-239. doi:10.5935/abc.20180052.

[12] Correale M, Totaro A, Ieva R et al.: Time intervals and myocardial performance index by tissue Doppler imaging. Int Emerg Med.: 2011: 6: 393–402. doi:10.1007/s11739-010-0469-3.

Sabit R, Bolton CE, Fraser AG, et al., (2010) Sub-clinical left and right ventricular dysfunction in patients with COPD. Respir Med 104: 1171–1178.

[13] Vitarelli A, Conde Y, Cimino E, et al.: Assessment of right ventricular function by strain rate imaging in chronic obstructive pulmonary disease. Eur Respir J. 2006: 27: 268–275. DOI: 10.1183/09031936.06.00072005.

[14] Bush A: Diagnosis of asthma in children under five. Prim Care Respir J.2007: 16(1): 7-15. doi: 10.3132/pcrj.2007.00001.

[15] Massoud MN, el Nawawy AA, el Nazar SY, et al.: Tumour necrosis factor-alpha concentration in severely asthmatic children. East Mediterr Health J. 2000: 6(2-3): 432-6.

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